INVESTIGATION OF THE EFFECTS OF TWIN-BLOCK APPLIANCES ON DEMINERALIZATION OF LOWER FIRST PREMOLAR

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ABSTRACT

Objective: The purpose of this study is to evaluate possible mineral losses in mandibular first premolars after the use of twin-block appliance, by enamel microhardness measurement method.
Materials and Methods: Twenty patients (12 females, 8 males; mean age=12.21±1.12) indicated as fixed orthodontic treatment with mandibular first premolar extraction after functional treatment with twin-block were included in the study. The twin-block appliance was used continuously (excluding meals) for 12 months. The appliance used in this research, which is a split-mouth study, was designed to cover the first premolar only on one side of the mandible, leaving the opposite the first premolar tooth exposed. After the extraction of the mandibular first premolars, two groups were formed: the teeth outside the appliance (Group I) and the teeth inside the appliance (Group II). Hardness measurements were calculated using Vicker's microhardness measuring device on the buccal and lingual regions of the both groups. 200 g load was applied to specimens for 10 sec. Two Independent Sample t test used in the statistical analysis of the data.
Results: A statistically significant difference was found between the hardness values of the buccal and lingual tooth regions of Group I and Group II ($p < 0.05$). Group II showed statistically significantly lower hardness values on both tooth regions (buccal region and lingual region) than Group I. In both groups, the hardness values on the buccal regions of the teeth were found to be significantly lower than the hardness values on the lingual regions ($p < 0.05$).
Conclusion: There is a possibility of mineral loss in the teeth remaining inside the appliance in treatments using the twin-block appliance.

Keywords: Demineralization, hardness, myofunctional treatment, twin-block

ÖZET

Amaç: Bu çalışmada amaç, twin-blok apareyi kullanımı sonrası alt birinci küçük azı dişlerinde olası mineral kayıplarını, mine mikrosertlik ölçümü yöntemi ile değerlendirmektir.
Materyal ve Metot: Çalışmaya, twin-blok ile fonksiyonel tedavi sonrası alt birinci küçük azı çekimli sabit ortodontik tedavi tanısı konan 20 hasta (12 kız, 8 erkek; ortalama yaş=12,21±1,12) dahil edilmiştir. Twin-blok apareyi, hastalara 12 ay boyunca tüm gün (yemekler hariç) kullandırılmıştır. Bölünmüş ağız çalışması olan bu araştırmada kullanılan aparey, birinci küçük azı dişini alt çenenin sadece bir tarafında kaplayacak ve karşıt birinci küçük azı dişini açıkta bırakacak şekilde tasarlanmıştır. Alt birinci küçük azı dişlerinin çekimi sonrası aparey dışında kalan dişler (Grup I) ve aparey içinde kalan dişler (Grup II) olmak üzere iki grup oluşturulmuştur. Her iki grubun yanak tarafına ve dil tarafına bakan yüzeylerinde Vicker's mikrosertlik ölçüm cihazı kullanılarak sertlik ölçümü yapılmıştır. 200 gr yük 10 sn süreyle uygulanmıştır. Verilerin istatistiksel analizinde, İki bağımsız örneklem t testi kullanılmıştır.
Bulgu: Grup I ve Grup II'nin, yanak tarafına ve dil tarafına bakan diş yüzeylerinin sertlik değerleri arasında istatistiksel olarak anlamlı bir fark bulunmuştur ($p < 0,05$). Grup II, her iki diş yüzeyinde (yanak yüzeyi ve dil yüzeyi) Grup I'e göre

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istatistiksel olarak anlamlı bir şekilde daha düşük sertlik değerleri göstermiştir. İki grupta da dişlerin yanak tarafına bakan yüzeylerindeki sertlik değerlerinin dil tarafına bakan yüzeylerindeki sertlik değerlerinden anlamlı bir şekilde düşük olduğu saptanmıştır (p <0,05).
Sonuç: Twin-blok apareyi kullanılarak yapılan tedavilerde, aparey içinde kalan dişlerde mineral kaybı oluşma ihtimali bulunmaktadır.

Anahtar Kelimeler: Demineralizasyon, fonksiyonel tedavi, sertlik, twin-blok

INTRODUCTION

Class II division 1 malocclusions are one of the most commonly treated problems in orthodontics (1). These anomalies are usually characterized by mandibular deficiency (2), and functional orthopedic treatment is applied in the treatment of these anomalies during the growth and development period (3). One of the most frequently used removable myofunctional appliances is the twin-block appliance (4, 5). The appliance includes upper and lower acrylic blocks that are extended from the lingual and labial surfaces of teeth (6). The appliance must be worn continuously (except meals) to maximize the effect (7). Dental plaque is shown as the main factor in dental caries formation (8). The increase in dental plaque increases the amount of carbohydrate and the number of bacteria in the plaque structure. Increased carbohydrate content increases plaque adhesion (9). Accordingly, the washing and buffering functions of the saliva are prevented, and it causes microorganisms and the organic acids produced by these microorganisms to remain in contact with the tooth structure for a longer period (8). When the amount of minerals separated from the tooth structure is higher than the amount of minerals added to the structure under the effect of organic acids that dental plaque bacteria produce by fermenting carbohydrates, a dental caries lesion starts to form on the surface of the tooth enamel. Due to the extended time of the direct contact of the twin-block appliance with the dental tissues, the neutralizing and self-cleaning functions of the saliva are reduced, increasing plaque retention and demineralization risk (7). This study aimed to detect possible mineral defects that threaten the integrity of the enamel structure associated with the use of the twin-block. The null hypothesis test was that the use of the twin-block appliance has no effect on mineral loss in the lower first premolar teeth.

MATERIALS AND METHODS

Twenty patients (twelve females, eight males; mean age = 12.21 ± 1.12) who were indicated as lower premolar extraction after twin-block therapy were included in this study. The investigation was designed as a split-mouth study. The Ethics Committee's approval was gained from Selcuk University Clinical Researches Ethics Committee (number 2016/30). G * Power (Ver 3.0.10., Franz Faul Universitat, Kiel, Germany) program was used to determine the number of universes in the study. In order for the teeth outside the appliance to have a higher hardness value compared to the teeth in the appliance, it was determined that the significance level and the effect size of the one-way test to be performed be 5% and 0.8, respectively. The required sample volume to reach at least 80% power was 20 individuals per group. The inclusion criteria were as follows;

- No prior orthodontic treatment
- Having Angle Class II division 1 malocclusion
- Functional orthodontic treatment indication by the extraction of lower first premolars
- Being in the period of growth and development (having fourth (S and H2) or fifth (MP3cap, PP1cap and Rcap) epiphysial stages on hand wrist radiographs that described by Björk (1972)
- Having good oral hygiene
- Having all permanent teeth in the mouth except third molars
- No enamel demineralizations which can be detected by visual inspection
- No previous enamel demineralization treatment
- Having no internal or external stains, defects, cavities and fillings in lower first premolars
- Having no intraoral or systemic disease
- Good co-operation expectation

Wrist X-ray images were taken at the beginning of the twin-block treatment and lateral cephalometric films were taken at the beginning (T0) and end of the twin-block treatment (T1) for all patients. Lateral cephalometric films were obtained as standard using a digital imaging system (Planmeca Promax, Dimax 3 Ceph, Helsinki, Finland). While the radiographs were taken, the patient's head was fixed using cephalostat ear rods. The lips were placed in the relaxed position. Care was taken to ensure that the Frankfort plane was parallel to the horizontal plane and the teeth were in centric occlusion. All cephalometric films were obtained by the same researcher following these rules. The lateral cephalograms obtained were analyzed using the computer program (Quick Ceph Image, Quick Ceph Systems Inc. California, USA) by the same researcher (E.U.M). The appliance used in the study was obtained by modifying Clark's original twin-block appliance. Adams clasps (0.7 mm round steel) were bent around the maxillary first molar teeth, and the labial bow was not bent. The upper appliance included a midline expansion screw. The lower appliance was retained by 0.7 mm round steel interdental ball-ended clasps in the lower incisor combined with Adams clasps in the mandibular first premolar teeth (only on one side). The appliance's acrylic base accommodated the first premolar tooth on one side while the first premolar tooth on the other side was outside of the appliance (Figure 1).

Figure 1: Modified twin-block appliance

Half of the patients (10 patients) were randomly chosen to have their lower first right molar teeth placed in the appliance, and the other half (10 patients) had their lower left first molar teeth included in the appliance. The 20 lower first premolar teeth that were outside the appliance comprised the control group (Group I), and the 20 lower first premolar teeth inside the appliance were the experimental group (Group II). Oral hygiene training was given to all patients before starting the study. During the treatment, the evaluation was made according to the Green Vermillion Oral Hygiene Index every month (10). Extra oral hygiene training was given to the patients who needed it and they were called for extra check-ups. In this way, it was ensured that the patients' scores remained 0. Before the appliance was installed, the buccal and lingual surfaces of the mandibular first premolar teeth of the patients were polished and smoothed by the application of 300, 600, and 800-grain silicon carbide abrasive paper for 20 seconds each, respectively. The modified twin-block appliances were worn continuously for 12 months (excluding meals). Due to the patients' need for fixed orthodontic treatment with extraction following the use of the twin-block appliance, the mandibular first premolar teeth were extracted before the onset of the fixed orthodontic treatment. The tissues and debris residues on the teeth were removed with distilled water and a sponge. After the extractions, the teeth were stored in distilled water at +4°C. The roots of the teeth were separated from the cementoenamel junction under water cooling using an aerator (CaWo, Germany) and a diamond bur (Meizen, Germany) (Figure 2).

Figure 2: Separation of teeth into crowns and roots

Next, the crowns of the specimens were sectioned mesiodistally with a diamond disc. Thus, two enamel samples (specimens), buccal and lingual, were obtained for each tooth. A total of 80 enamel specimens were embedded in acrylic blocks in standard thickness rings such that the convex tooth surfaces were as parallel as possible (Figure 3). Quantitative surface microhardness of the enamel samples was detected with a digital display Vickers microhardness tester device (Microbul-30-N, Micro Vickers Hardness Tester, Bulut Corporation, Turkey). The enamel samples obtained from the patients were placed under the test microscope, and the microscope table was adjusted until a clear image was obtained with a ×40 magnification eyepiece. A load of 200 g was applied to the specimens for 10 sec. The diagonal length of the mark formed by the diamond tip on the enamel was measured in microns. The microhardness value relationship was automatically calculated by the device and recorded on the device's screen as the Vickers Hardness Value.

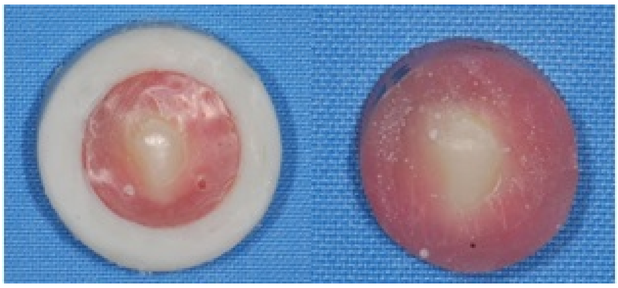

Figure 3: Enamel specimens were embedded in acrylic blocks

Statistical Analysis

All statistical analyses were performed with R Studio software version 3.2.1. When P value is less than 0.05, it was considered statistically significant. Standard deviations and arithmetic means were calculated for each measurement. The normality test of Kolmogorov-Smirnov was applied to the data, and the data were determined to be normally distributed. Paired samples t-Test was used to statistically evaluate the difference (T1-T0) values between (T0) and (T1) of the cephalometric measurements. Student's t-tests were used in the statistical evaluation of the microhardness measurements.

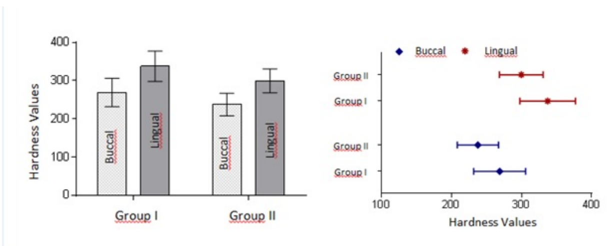

Figure 4: Mean and standard deviation values of hardness measurements

Table 1: Descriptive information of cephalometric variables and pretreatment (T0) and post-treatment (T1) mean values and standard deviations

Cephalometric Variables	T0 (n=20)		T1 (n=20)		T1-T0(n=20)		
Mean	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P**
SNA	80.89	1.69	79.89	2.36	-1.00	1.63	**0.012**
SNB	74.36	1.34	75.81	2.56	1.46	1.84	**0.002**
ANB	6.53	0.85	4.08	0.62	-2.46	0.96	<**0.001**
Mandibular length	60.65	3.28	62.41	4.26	1.77	3.53	**0.038**
Co- Gn (mm)	102.06	5.53	107.83	4.74	5.72	1.92	<**0.001**
Co-A (mm)	83.12	2.15	83.43	2.11	0.25	1.91	0.468
Lower anterior facial height (ANS-Me) (mm)	59.48	3.90	62.99	3.27	3.51	1.96	<**0.001**
SN-GoGn	36.86	1.57	37.60	2.98	0.80	2.52	0.207
SN-Palatal plane	12.19	1.91	12.34	1.62	0.31	1.91	0.736
SN-Occlusal plane	25.05	3.32	24.87	3.88	-0.19	2.50	0.744
Posterior facial height (Jarabak) (S-Go) (mm)	59.64	3.28	69.41	3.31	9.77	2.80	<**0.001**
Anterior facial height (Jarabak) (N-Me) (mm)	104.86	4.53	110.55	5.05	5.69	2.65	<**0.001**
Mx 1–SN	106.72	8.46	104.75	6.92	-1.98	2.92	**0.007**
Mx 1-Pal	-61.57	9.61	-62.88	8.44	-1.31	2.51	**0.03**
Mx 1-NA (mm)	6.85	0.61	6.41	0.84	-0.49	0.56	**0.004**
Mx 1-NA (°)	27.62	2.76	24.48	2.74	-3.14	0.90	<**0.001**
IMPA	103.22	5.25	107.60	5.59	3.84	1.10	<**0.001**
Md 1-NB (°)	34.39	2.08	40.86	2.71	6.48	1.43	<**0.001**
Md 1-NB (mm)	7.76	0.73	9.79	0.98	2.14	0.79	<**0.001**
Aestheticplane-Upper Lip	0.15	0.95	-1.20	1.13	-1.34	1.29	<**0.001**
Aesthetic plane-Lower Lip	1.25	0.63	1.34	0.58	0.13	0.58	0.507

Bold texts indicate statistically significant groups, P: Significance value of paired sample t-test, Mean: Average SD:Standard Deviation, p <0.05 value was used for statistical

RESULTS

Pre- and post-treatment mean values and standard deviations of the cephalometric variables are presented in Table 1. The findings revealed a significant decrease in SNA, ANB, Mx 1-SN, Mx 1 - NA (mm), Mx 1 - NA (deg), Aesthetic plane-Upper Lip. There was significant increase in SNB, IMPA, Md 1 - NB (deg), Md 1 - NB (mm), Mandibular length, Co- Gn, Lower anterior facial height, Posterior facial height, Anterior facial height, Md 1 - NB (mm).
The results of the Student's t-tests used to compare the hardness variables are presented in Table 2 and Figure 4. According to the data obtained, there was a significant difference in the enamel hardness between the groups ($p < 0.05$). The hardness values of the buccal and lingual regions of the teeth that were inside the appliance (Group II) were found to be significantly lower than those of the teeth that remained outside the appliance (Group I). Buccal enamel hardness values were less than lingual enamel hardness in both groups, and this difference was statistically significant. Based on the significant differences between the control and experimental groups, the null hypothesis of the present study can be rejected.

DISCUSSION

In the study, the modification in the design of the appliance aiming to evaluate the effect of the twin-block appliance on possible mineral loss in mandibular first premolars, did not alter the efficacy of the appliance. Similar to the present, subsequent to twin-block therapy, a decrease in SNA (11-13), ANB (13-17), Mx 1- SN (15-17), Mx 1- NA (mm) (15, 18, 19), Mx 1- NA (deg) (15, 17, 19), Aesthetic plane-Upper Lip (17, 18, 20) and an increase in SNB (13-17), IMPA (13, 14, 16, 17), Md 1- NB (deg) (13, 14, 16, 17), Md 1-NB (mm) (13, 14, 16), Mandibular length (13-15), Co-Gn (17, 19) have been reported in the literature. In accordance with the findings of the current study, there are studies reporting an increase in the vertical facial height with twin-block treatment (13, 16, 17). On the tooth surface adjacent to an orthodontic appliance, an acidic environment develops due to increased retention of dental plaque and the number of cariogenic bacteria in the plaque; thus enamel demineralization can occur (7). Published studies that evaluated the effect of orthodontic treatment on mineral losses have generally been conducted on patients undergoing fixed orthodontic treatment (21, 22). Few studies have evaluated the effect of removable orthodontic appliances on demineralization (7, 23, 24). This study compared the hardness values of patients' mandibular first premolar teeth inside and outside a twin-block appliance, a removable functional appliance, to determine the possible demineralization formation as a result of using the appliance. The hardness test was chosen to assess demineralization because surface microhardness is a physical feature of the enamel surface and dental tissue gives

Table 2: Results of Inter-group and Intra-group Comparison Findings

	Buccal (n=20)				Lingual (n=20)				P
Groups	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	
Group I	268,86	37,06	197,70	316,50	337,47	39,69	264,42	378,45	**<0,001**
Group II	237,83	29,41	202,20	289,05	299,75	31,20	238,26	363,66	**<0,001**
Intergroup-p value	**0.006**				**0.002**				

P: Significance value of Student's t test, Mean: Average, SD: Standard Deviation, Min: Minimum, Max: Maximum, p <0.05 for statistical significance was used.

information about the mineral content (25). It has been reported in the literature that demineralization characterized by frequent ion loss can be detected by a decrease in the enamel microhardness (26). The patients who needed fixed orthodontic treatment with extraction following the twin-block treatment were included in the study due to the ability to perform in vitro microhardness tests. Treatment with a twin-block appliance can cause an increase in the angle between the long axis of the mandibular incisor teeth and the mandibular plane (11). The increase in the angle of mandibular incisors with the functional treatment increases the possibility of recurrence and can lead to the need for fixed orthodontic treatment with extraction (27). Because enamel hardness varies across teeth and tooth surfaces (buccal, lingual) (28) due to differences in the enamel's chemical content, this study compared the hardness values of the buccal and lingual surfaces of the lower right and left first premolar teeth of the same patient. Thanks to the splint mouth working design, all individual risk factors that could affect decay formation were excluded because of two groups consisted the same patients. Similar to Zheng (29), the teeth extracted after the twin-block therapy were stored at $+4^oC$ in distilled water until the day when the study was performed. Herkströter's (30) studies were referenced in the preparation of the samples; enamel specimens were embedded in acrylic blocks in rings of standard thickness. After the twin-block treatment, no procedure was performed to the tooth surfaces except for cleaning the surface residues with distilled water and a sponge. Before the hardness test measurement, the teeth were dried with napkins, thereby preventing erroneous measurements which could occur due to refraction of the wet enamel. The hardness was measured on the surface of the enamel because enamel hardness decreases from the enamel's outer surface in toward the dentine (28). Enamel hardness measurements were made in several different areas on the surface of each sample, and the results were averaged. If one values differed significantly from the others, it was excluded from the calculations.The load and time applied to the surface of the specimens to determine enamel hardness has varied across different studies. One study used a load of 300 g for 10 sec (Chaudhary) (31), while another used a load of 1 N for 15 sec (Adebayo) (32). The present study followed Montasser (33) and used a load of 200 g for 10 sec to determine enamel hardness. Previous studies have reported that enamel hardness is highly variable. The hardness values of the enamel reported by Craig Peyton (34) were 344 ± 49 and 418 ± 60 (VHN) Colly (35) 369 ± 25 and 431 ± 35 VHN, and Wilson Love (36) 263 ± 26 and 327 ± 40 VHN. Meredith (37) reported enamel hardness between 270 and 360 VHN and Gutiérrez Salazar Reyes-Gasga (38) between 272 and 440 (KHN). These variations depended on the histological structure, chemical composition, specimen preparation, applied load, and time (38). Due to these documented variations in enamel hardness, comparing the same surfaces of the same group of teeth of the same patient minimized these potential variations. For these reasons, two teeth from the same patient were compared.Similar to the demineralization associated with twin-block appliances in our study, Dixon (7) reported that demineralization occurred in the mandibular buccal segment in five patients using a twin-block appliance with an acrylic extension in the mandibular anterior region. He surmised that even when the oral hygiene was excellent, mineral losses might occur due to the use of carbonated drinks. It has been reported in the literature that 16% of twin-block patients are unable to use their appliance consistently (39). However, the cases in which demineralization occurred consisted of patients who used the appliance properly. This outcome may be because the twin-block treatment affects the washing, buffering, and remineralizing properties of the saliva and reduces salivary functions. If the acrylic coating, oral hygiene, appliance care, and nutrition instructions are not followed, a potential plaque-holding stagnation area is formed. Saliva acts as a buffer when in contact with the teeth. It can neutralize the acidic effect and prevent the mineral loss of the tooth structure (40). The balance between the demineralization and remineralization phenomena is distorted by the change of the ecological environment due to the formation of a sheltered area by the twin-block appliance that causes plaque retention around the teeth and the inhibition of salivary functions (7). Organic acids that dental plaque bacteria produce as a result of the fermentation of carbohydrates can reduce the pH of the medium. When the pH value of saliva decreases below the critical value of 5.5, the saturation of the medium with Ca^{+2} and PO_4^3 ions will decrease, and minerals will pass from the tooth's hard tissues into the medium tissues (41), increasing the risk of mineral loss from dental hard tissue. Alexander (23) assessed the effects of fixed orthodontic appliances and removable functional appliances on enamel decalcification in 41 individuals and on 164 first molar teeth. He used a Bionator as the functional appliance. He reported that while new white spot lesions develop in the group undergoing fixed orthodontic appliances during treatment, they did not in those undergoing removable functional appliance treatment. The results of that study may differ from the present study due to the type of appliance used. The lower part of the Bionator appliance is narrower, with no acrylic extension covering the mandibular incisors. There is no acrylic extension into the palate, and the proprioceptive relationship of the tongue with the palate continues. Thus, the oral environment may not have changed the way the dental caries form because of these factors. A study using a full-time Essix retainer reported that severe mineral losses occurred in dental hard tissues (24). While extensive demineralization was observed in the mandibular dental arch of the patient, demineralization was limited in the maxillary dental arch. The patient had extensive dental caries on the incisal edges of the mandibular incisor teeth and in the mandibular first premolar teeth. Early dental caries lesions were formed only in the maxillary right canine tooth and maxillary first molar tooth in the maxillary dental arch. Accordingly, the authors reported that the use of an Essix retainer might contribute to dental caries formation. The Essix retainer reportedly reduced saliva's ability to clean and buffer the teeth by creating a medium that allowed carbonated drinks to accumulate around the teeth and limit saliva flow (24). The enamel structure of new teeth in young patients is very porous. Under normal conditions, salivary minerals become diffused into the tooth structure and cause changes in the outer surface content of the enamel called enamel maturation. This change reduces the solubility of dental hard tissues and increases resistance to dental caries attacks (42). Chaussain (43) and Zimmer Rottwinkel (44)) reported that orthodontic treatment applied during the adolescent period constitutes a risk factor for mineral loss and dental caries formation due to the young permanent tooth enamel. Consistent with this information, it is thought that the reduced hardness values of teeth inside the appliance and the mineral losses found in this study are due to increased potential plaque retention, inhibited salivary functions during the use of the twin-block appliance, and the porous structure of young permanent tooth enamel. This study's limitations are the application of the hardness measurements in vitro, the design of the splint mouth, the attachment of the appliance to the patient, and the length of treatment. Mineral demineralization should be minimized by careful selection of patient and appliance, oral hygiene recommendations, fluoride application, and nutritional supplements (45).

CONCLUSION

This study investigated the effect of therapy with a twin-block appliance on tooth decay formation to exclude other risk factors that have the potential to cause caries; the same patients' teeth inside and outside of the appliance were examined following treatment. Both the buccal and lingual surfaces of the teeth inside the appliance had lower hardness values than the same surfaces of the teeth outside the appliance. Therefore, this study showed that the use of a twin-block appliance may affect the formation of dental caries.

Ethics

Selcuk University Clinical Researches Ethics Committee (number 2016/30)

Authorship Contributions

Writing and data collection: E.U.M., Concept and Design: M.A., all authors read and approved the final version of the manuscript.

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Declaration of competing interest:

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